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Stemflow: A Source of Nutrients in some Naturally Growing Epiphytic Orchids of the Sikkim Himalaya

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A study on five naturally growing epiphytic orchids *viz.*, *Bulbophyllum affine* Lindl., *Coelogyne ochracea* Lindl., *Otochilus porrecta* Lindl., *Cirrhopetalum cornutum* Lindl. and *C. cornutum* (var.) was carried out in the subtropical belt of Sikkim Himalaya. Stemflow leachates formed the main source of ammonium-N and nitrate-N for uptake by these orchids. Phosphorus concentration in the tissues of these orchids was high. Phosphate-P from stemflow does not seem to be a regular source of phosphorus for these orchids. Absorption/desorption results indicate that organic-N from stemflow leachates is not utilized by these orchids.

Key words: Epiphytic orchids, stemflow, nutrients, enrichment ratio, absorption/desorption.

INTRODUCTION

The Orchidaceae is one of the largest families of the flowering plants. Out of about 17000 species known to occur in the warm humid tropics of the world, nearly 1300 species are believed to occur in India (Arora and Mukherjee, 1983). Sikkim, with an area of 7096 km^2 and having an elevation range of 300–8500 m above mean sea level, is reported to harbour about 450 species of orchids. Epiphytic orchids grow mainly on the trunks or branches of different trees (phorophytes) fixing themselves with strong fascicular and stout spongy roots. Alexander and Hadley (1983) have reported enhanced growth rate and increased phosphorus concentration in *Goodyera repens* tissues as a result of mycorrhizal infection. Alexander, Alexander and Hadley (1984) have also worked on phosphate uptake in relation to mycorrhizal infection in the same species. Dijk (1989) has shown the effects of mycorrhizal fungi on *in vitro* nitrogen response of juvenile orchids. Growth and nutrient uptake have been reported in various species of orchids grown with different nutrient solutions, potting media, compost and fertilizers (Tanaka *et al.*, 1988*a*, *b*, 1989). However, information on the nutrient sources of naturally growing epiphytic orchids is lacking. Therefore the present study was planned to assess the significance of stemflow leachates as a source of nutrients in five epiphytic orchids of the warm humid subtropics in Sikkim.

STUDY SITE AND METHODS

The study was undertaken in the forest of ICAR (Indian Council of Agricultural Research) which is situated between 1225 and 1300 m above mean sea level. The selected forest is dominated by *Schima wallichii* Chois, on which different species of epiphytic orchids are found growing naturally. The selected site of experimentation is situated in the subtropical belt of Sikkim Himalaya. The topography is sloping and the forest is dense with a closed canopy. Five species of epiphytic orchids *viz.*, *Bulbophyllum affine* Lindl., *Coelogyne ochracea* Lindl., *Otochilus porrecta* Lindl., *Cirrhopetalum cornutum* Lindl. and *C. cornutum* (var.) were selected for the present study and identified using King and Pantling (1898).

Chlorophyll content was estimated in freshly harvested leaves and bulbs of each species following Maclachlan and Zalik (1963). Component biomass of mature plants was measured after drying the samples in an oven at 65 °C until constant weight was achieved. Nitrogen and phosphorus contents of different plant components were determined using oven dried milled samples. Nitrogen was estimated by a modified micro-Kjeldahl method, and phosphorus was estimated by colorimetry using ascorbic acid as reductant (Anderson and Ingram, 1992).

Percentage absorption and desorption of ammonium-N, nitrate-N, organic-N and phosphate-P were estimated using stemflow samples. The stemflow was collected in 2·5 l capacity plastic jerry cans below each species of epiphytic orchid using aluminium sheet around the stem for streamlining the collection. Samples of stemflow for control (without epiphytic orchids) were collected from the same species of phorophytes with similar stem and canopy dimensions. A total of nine stemflow events for each species was recorded along with collection of rainfall in an open space. Rainwater and stemflows collected below epiphytic orchids and the control were brought to the laboratory immediately after each rainfall event for analysis. The pH of stemflow and rainwater samples was measured using a glass electrode digital pH meter. Estimation of organic-N of stemflow and rainwater samples was made by distillation

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TABLE 1. *Biomass (per plant), chlorophyll and nutrient concentrations of plant components of five epiphytic orchids. Values are mean ± s.e.*

Species	Component	Biomass (g)	Moisture (%)	Chlorophyll (mg g^{-1}) a	Chlorophyll (mg g^{-1}) b	Total nitrogen (%)	Phosphorus (%)
Bulbophyllum affine	Leaf	10·5 ± 1·44	87	0·115 ± 0·001	0·100 ± 0·001	0·45 ± 0·011	0·28 ± 0·001
	Bulb	7·0 ± 0·60	81	0·087 ± 0·002	0·073 ± 0·002	0·41 ± 0·008	0·19 ± 0·006
	Root	4·5 ± 1·15	67	— —	— —	0·58 ± 0·014	0·31 ± 0·006
Coelogyne ochracea	Leaf	3·5 ± 0·87	85	0·268 ± 0·005	0·177 ± 0·003	0·51 ± 0·009	0·29 ± 0·006
	Bulb	9·5 ± 0·29	87	0·104 ± 0·001	0·031 ± 0·001	0·35 ± 0·003	0·18 ± 0·002
	Root	2·5 ± 0·28	38	— —	— —	0·51 ± 0·009	0·28 ± 0·001
Otochilus porrecta	Leaf	3·0 ± 0·69	68	0·595 ± 0·001	0·355 ± 0·002	0·78 ± 0·005	0·31 ± 0·006
	Bulb	6·5 ± 1·15	88	0·058 ± 0·003	0·055 ± 0·005	0·26 ± 0·002	0·16 ± 0·010
	Root	5·5 ± 0·29	65	— —	— —	0·52 ± 0·011	0·32 ± 0·001
Cirrhopetalum cornutum	Leaf	3·5 ± 0·87	85	0·193 ± 0·002	0·112 ± 0·001	0·77 ± 0·015	0·30 ± 0·006
	Bulb	7·0 ± 1·16	88	0·070 ± 0·003	0·030 ± 0·002	0·44 ± 0·567	0·11 ± 0·006
	Root	4·0 ± 0·58	40	— —	— —	0·57 ± 0·011	0·26 ± 0·010
Cirrhopetalum cornutum (var.)	Leaf	3·0 ± 0·60	88	0·155 ± 0·002	0·135 ± 0·003	0·71 ± 0·009	0·28 ± 0·003
	Bulb	3·0 ± 1·52	91	0·056 ± 0·002	0·061 ± 0·004	0·50 ± 0·016	0·21 ± 0·006
	Root	1·0 ± 0·15	67	— —	— —	0·47 ± 0·005	0·31 ± 0·006

after digestion, whereas for ammonium-N and nitrate-N a direct distillation method was followed. Distillation was done using a Kjeldahl unit, and organic-N, ammonium-N and nitrate-N were estimated gravimetrically following Allen (1989).

Nutrient enrichment in stemflow, with and without orchid species, over rainwater was calculated by taking the ratio of nutrient concentration in stemflow and rainwater. Percentage nutrient absorption and desorption in stemflow collected below each orchid species, as against stemflow without orchid (control), were calculated.

RESULTS AND DISCUSSION

Total dry matter biomass per plant was highest in *B. affine* (22 g) followed by *C. ochracea* (15·5 g), *O. porrecta* (15 g), *C. cornutum* (14·5 g) and *C. cornutum* var. (7 g). Shoot:root ratio was highest (6·0) in *C. cornutum* var. followed by *C. ochracea* (5·20), *B. affine* (3·89), *C. cornutum* (2·63) and lowest (1·73) in *O. porrecta* (Table 1). Pooled data for all species on dry matter allocation in different components was 44·6 % in the bulb, 31·8 % in the leaf and 23·6 % in the root. Moisture was lower in roots as against very high content in bulbs and leaves (Table 1). Chlorophyll a in both leaves and bulbs was higher than chlorophyll b in all the species of orchids. Total chlorophyll content averaged over species was relatively higher in leaves (0·45 mg g^{-1}) than in bulbs (0·12 mg g^{-1}). Leaf total chlorophyll was maximum in *O. porrecta* (0·95 mg g^{-1}) whereas it was minimum in *B. affine* (0·26 mg g^{-1}). Percentage total nitrogen varied between 0·26 and 0·78 in different components of orchids (Table 1). In roots, nitrogen was higher in *B. affine* (0·58 %) and this value exceeded the values in the leaf (0·45 %). Pooled nitrogen concentration for all species component-wise was highest in leaves (0·64 %) followed by roots (0·53 %) and bulbs (0·39 %). Phosphorus concentration was higher in roots in *B. affine* and *C. cornutum* var. than in bulbs and leaves, whereas root and leaf values were nearly equal in *C. ochracea* and *O. porrecta* (Table 1). Pooled values of phosphorus were nearly of the same magnitude in leaves and roots (0·30 %) whereas they were lower in bulbs (0·17 %). Phosphorus concentration in plant tissue was high in the studied orchids. This confirms the report of Alexander and Hadley (1983) which shows that mycorrhizal infection in the orchid *Goodyera repens* brings about an enhanced growth rate and increased phosphorus concentrations in the tissues.

Antecedent rainfall for 5 d at the day of stemflow collection was recorded and is presented in Figs 1 to 4 for comparison with nutrient absorption and desorption. Total rainfall during the period Aug. to Oct. 1993 at the study site was 1159 mm. The pH of rainwater was neutral (6·9) and the stemflow water was acidic (5·4–6·0). The lowest pH value of 5·4 was recorded in stemflow collected below *C. cornutum* (var.) (Table 2).

Ammonium-N absorption and desorption from stemflow passing through orchids varied between the different species (Fig. 1). In the case of *B. affine* no desorption was observed at any of the nine events of the study; however, absorption fluctuated at different dates. It was observed that the absorption rate decreased when the rainfall was of higher intensity and continued for a longer period. Although desorption of ammonium-N was recorded on a few dates in the other four species the magnitude was very low as compared to absorption. The nutrient enrichment ratio for ammonium-N in stemflow as against rainwater also followed a similar trend. Pooled absorption (11–28 %) recorded in this study (Table 2) clearly indicates that all the five species depend partly on stemflow ammonium-N for their nitrogen requirement.

Nitrate-N at different dates shows both absorption and desorption (Fig. 2). Nitrate-N absorption increased between the first and second dates followed by desorption by the

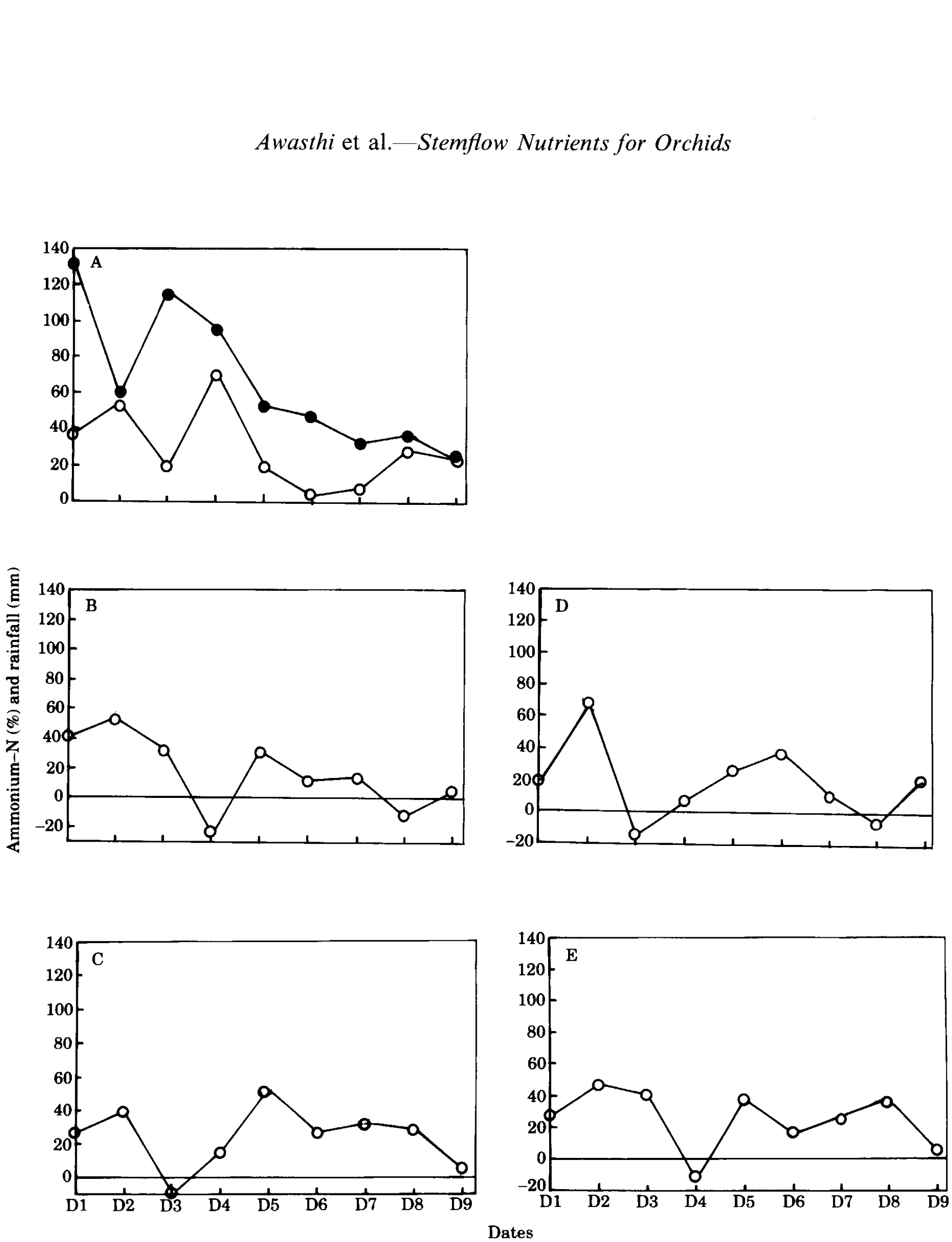

FIG. 1. Absorption (positive values) and desorption (negative values) of ammonium-N in different epiphytic orchids of Sikkim. A, *Bulbophyllum affine*; B, *Coelogyne ochracea*; C, *Otochilus porrecta*; D, *Cirrhopetalum cornutum*; E, *Cirrhopetalum cornutum* (var.). (●——●) Rainfall (5 d antecedent) and (○——○) absorption/desorption. D1 = 10 Aug. 1993; D2 = 19 Aug. 1993; D3 = 23 Aug. 1993; D4 = 30 Aug. 1993; D5 = 16 Sep. 1993; D6 = 21 Sep. 1993; D7 = 24 Sep. 1993; D8 = 28 Sep. 1993; D9 = 11 Oct. 1993.

third sampling date. Pooled values for the entire study period indicate absorption (16–24%) in four species and desorption of about 4% in *C. cornutum* (var.) (Table 2). Nitrogen requirements of these epiphytic orchids are partially fulfilled from nitrate-N absorption from stemflow leachates.

Organic-N in rainwater was lowest (0·24 mg l^{-1}), and the highest value of 0·84 mg l^{-1} was recorded in stemflow collected below *C. ochracea* (Table 2). Only in the case of stemflow collected below *O. porrecta* was the organic-N concentration lower than the stemflow (without orchid) control. In all five species of orchids, the absorption and

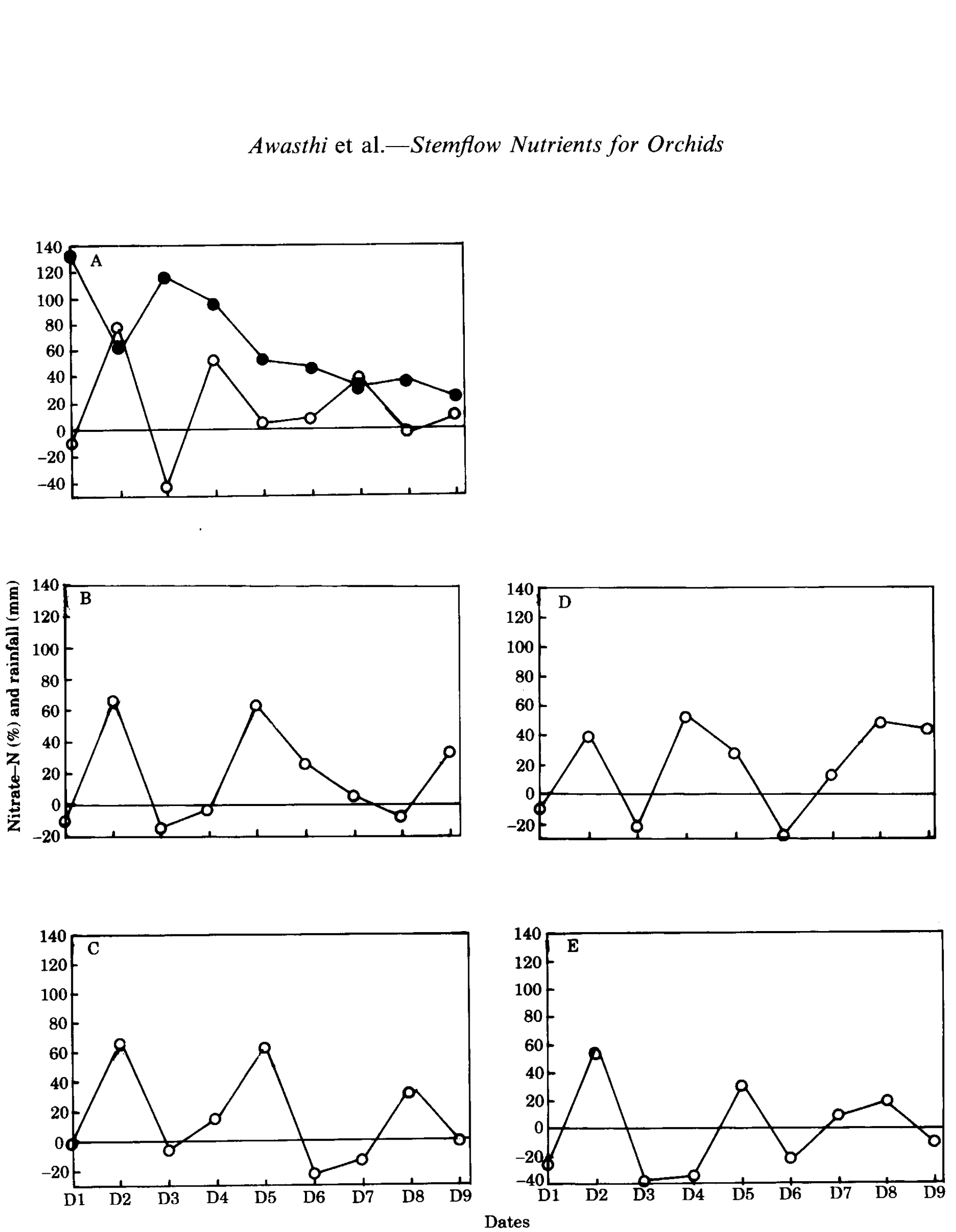

FIG. 2. Absorption (positive values) and desorption (negative values) of nitrate-N in different epiphytic orchids of Sikkim. A–E as in Fig. 1. (●——●) Rainfall (5 d antecedent) and (○——○) absorption/desorption. D1 to D9 as in Fig. 1.

desorption varied at different dates of experimentation (Fig. 3). Pooled absorption/desorption of organic-N for all nine events of the studies indicate that, except for *O. porrecta*, all the species had desorption (Table 2). Desorption in stemflow could be from orchid plant parts or detritus collected at the place where the orchid is positioned on the phorophyte. It appears that these epiphytic orchids scarcely use organic-N as a nitrogen source.

Phosphate-P concentration in stemflow collected below most of these orchids was higher than the stemflow control except under *B. affine* where it was lower. The highest concentration was recorded in stemflow collected below *C.*

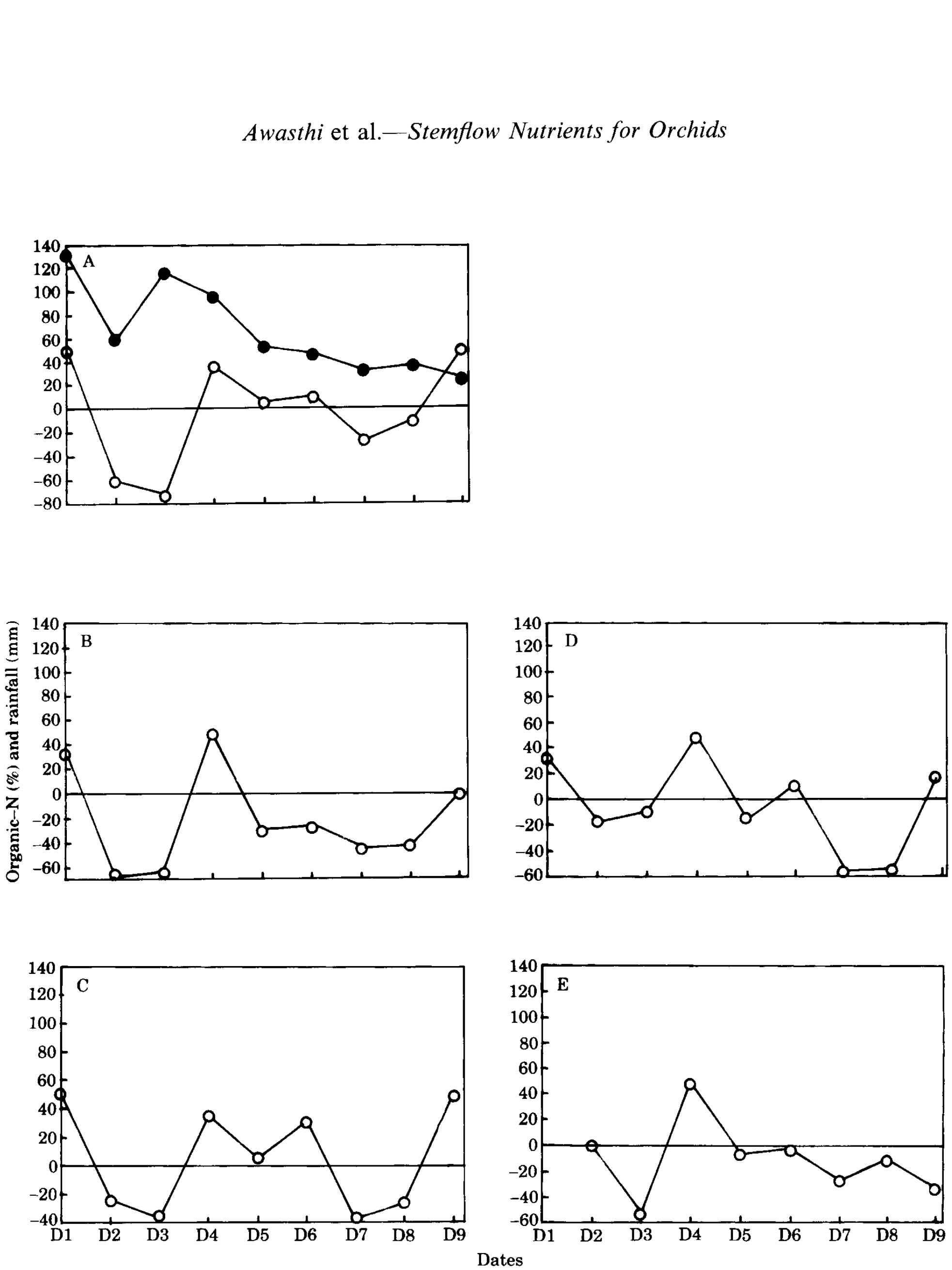

FIG. 3. Absorption (positive values) and desorption (negative values) of organic-N in different epiphytic orchids of Sikkim. A–E as in Fig. 1. (●——●) Rainfall (5 d antecedent) and (○——○) absorption/desorption. D1 to D9 as in Fig. 1.

ochracea which was about 17 times higher than rainwater. Absorption and desorption at different dates in different species varied considerably (Fig. 4). Desorption of phosphate-P observed at different dates of study was quite pronounced in most of the orchid species. Phosphate-P enrichment ratio as against rainwater was highest (9·1–17·4) in comparison with all the three forms of nitrogen (Table 2). Normally, the phosphorus source in orchids is through mycorrhizal uptake (Alexander and Hadley, 1983; Alexander *et al.*, 1984) and absorption may take place selectively, depending on species, as observed in *B. affine*. In other species, negligible absorption or considerable desorption

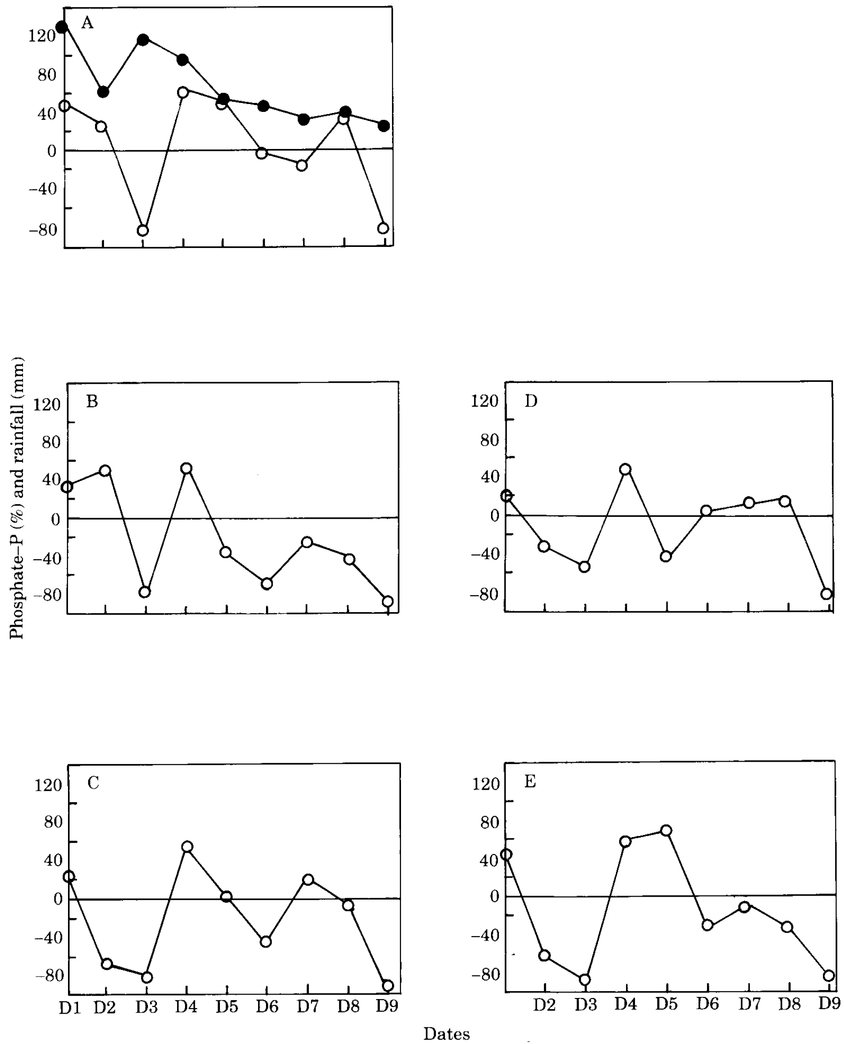

FIG. 4. Absorption (positive values) and desorption (negative values) of phosphate-P in different epiphytic orchids of Sikkim. A–E as in Fig. 1. (●——●) Rainfall (5 d antecedent) and (○——○) absorption/desorption. D1 to D6 as in Fig. 1.

suggests phosphate-P from stemflow is not a regular source of phosphorus in epiphytic orchids. The source of mycorrhizal phosphorus uptake is expected to be decaying detritus at the place where the orchids are positioned on the phorophyte.

Phosphorus in plant tissues of all five orchids was high. Phosphate-P from stemflow does not seem to be a regular source of phosphorus in these orchids. Stemflow ammonium-N and nitrate-N form the main nitrogen supply for these epiphytic orchids. It appears that organic-N from stemflow leachates are not utilized by these orchids. It is observed that both stemflow and decaying detritus accu-

TABLE 2. *The pH and nutrient concentration in rainwater, stemflow (control, without orchid) and stemflow (treatment, with orchid spp), and enrichment ratio and absorption/desorption in stemflow collected under different species of epiphytic orchids. Values of nine rainfall events are pooled*

Parameter	pH	Ammonium-N	Nitrate-N	Organic-N	Phosphate-P
Nutrient concentration (mg l^{-1})					
Rainwater	6·9	0·39	0·28	0·24	0·014
Stemflow (control)	5·8	1·59	1·35	0·55	0·178
Sp1 Stemflow	5·6	1·15	1·10	0·67	0·128
Sp2 Stemflow	5·9	1·41	1·09	0·84	0·243
Sp3 Stemflow	5·8	1·18	1·14	0·50	0·198
Sp4 Stemflow	6·0	1·29	1·03	0·59	0·197
Sp5 Stemflow	5·4	1·23	1·41	0·61	0·177
Nutrient enrichment ratio†					
Stemflow (control)		4·1	4·8	2·3	12·7
Sp1 Stemflow		3·0	3·9	2·8	9·1
Sp2 Stemflow		3·6	3·9	3·5	17·4
Sp3 Stemflow		3·0	4·1	2·1	14·1
Sp4 Stemflow		3·3	3·7	2·5	14·1
Sp5 Stemflow		3·2	5·0	2·5	12·6
Nutrient absorption/desorption* (%)					
Sp1 Stemflow		28	19	−18	28
Sp2 Stemflow		11	19	−35	−27
Sp3 Stemflow		26	16	9	−11
Sp4 Stemflow		19	24	−7	−10
Sp5 Stemflow		25	−4	−0	1

* Positive values indicate absorption while the negative (−) values indicate desorption.
† Ratio of nutrient concentration in stemflow with and without orchid species to that of rainwater.
Sp1, *Bulbophyllum affine*; Sp2, *Coelogyne ochracea*; Sp3, *Otochilus porrecta*; Sp4, *Cirrhopetalum cornutum*; Sp5, *Cirrhopetalum cornutum* (var.).

mulated at the position of the orchid on the phorophyte are the main source of nutrients in epiphytic orchids. Epiphytic orchids mostly grow in humid conditions and in the absence of rainfall the detritus nutrient release is expected to be utilized by mycorrhizal association.

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